DLA-95-P50017

A DLA STUDY ON THE COSTS OF REDUCING DEPOT PROCESSING AND TRANSPORTATION TIME

SEPTEMBER 1995

FOR

DEPARTMENT OF DEFENSE
DEFENSE LOGISTICS AGENCY
Executive Director, Materiel Management
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INSIGHT THROUGH ANALYSIS

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This is a report of a study conducted at the direction of the OSD Logistics Response Time PAT on DLA managed material. The report alone is incomplete in the sense that it is intended to be combined with similar analysis on service managed materiel and identification of the potential benefits. As such the conclusions and recommendations in the report have not been briefed to the Director, Defense Logistics Agency, and thus are not approved positions of the Agency.

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FOREWORD

The Department of Defense Logistics Strategic Plan, 1994 Edition, prepared by the Office of the Deputy Under Secretary of Defense (Logistics), states as one of its desired outcomes the restructuring of the logistics process to achieve a "better, faster, more precise, and highly mobile response capability." The number one stated goal is to "reduce logistics response times." A Department of Defense Inter-Service Process Action Team (PAT) was formed to facilitate the attainment of this goal. In November 1994, DLA Supply and Distribution Directorates tasked the DLA Operations Research Office to estimate the costs for DLA to reduce depot processing and transportation time. The PAT was invaluable in helping to define and guide our research efforts in pursuit of this objective. This analytical report documents our analysis and findings.

HAROLD BANKIRER
Colonel, USA
Chief, DLA Operations Research Office

EXECUTIVE SUMMARY

The Defense Logistics Agency (DLA) has made significant gains in providing a faster, more efficient logistics response capability. These enhancements help to maintain the logistical advantage our warfighters enjoy. Efforts in DLA's three primary business areas of Supply, Depot Operations, and Procurement have made this happen. In many cases, improvements were made at little or no additional cost.

Every inch that we can take off of the logistics pipeline is known to result in reduced customer inventories; and therefore, reduced costs to the taxpayer. However, unlike many other efforts, this report addresses response time reductions in areas that are known to have cost implications to wholesale organizations. Many logisticians believe that these costs will be minimal in light of the potential retail inventory reductions associated with faster wholesale replenishment. In this report we quantify the costs incurred by DLA as depots reduce requisition bank time, hold time, and in-transit time. Furthermore, we investigated different stock positioning issues relating to range and depth of stock in order to provide a reduced response time at the lowest possible cost.

Our analysis indicates that DLA can reduce average system response time for immediate depot issues by two days for an additional annual cost of $12.4 million in depot labor and second destination transportation. The depot labor cost represents overtime required to handle daily workload surges, while the transportation cost results from less materiel consolidation time. The additional $12.4 million annual cost would give DLA a four day average response time for issues of any in-stock item anywhere within the Continental United States. With 14.3 million stock issues per year, this equates to 87 cents per issue.

The cost to obtain a three day average response time is $39.5 million annually. Driving this result is the increased use of air freight rather than surface Less-Than-Truckload shipments. Expanding the use of dedicated truck deliveries can reduce this cost without significantly increasing response time. DLA would benefit from further analysis on potential delivery routes and stop-offs for dedicated trucks.

To reduce system response time, DLA should not try to increase inventory depth beyond standard distribution site allocations. Furthermore, DLA should not try to significantly increase the geographic support areas for facilities that are not Primary Distribution Sites. Demand variability within a geographic support area as well as the potential for greater economies of scale lead us to conclude that the Primary Distribution Sites can make up most of the response time deficiencies at a lower system cost. Minor enhancements to the geographic configuration of the DLA stock positioning policy, while not a cost nor system response time driver, may provide tailored support to improve DLA's service to selected customers.

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SECTION 1
INTRODUCTION

The Department of Defense Logistics Strategic Plan, 1994 Edition, prepared by the Office of the Deputy Under Secretary of Defense (Logistics), states as one of its desired outcomes the restructuring of the logistics process to achieve a "better, faster, more precise, and highly mobile response capability." The number one stated goal is to "reduce logistics response times." We know that each day of delayed response to the user represents millions of dollars in pipeline inventories waiting to be moved, repaired, delivered, stowed, and used. As our customers become more aware of the potential savings available through reduced inventories at the user level, they are demanding quicker and more reliable response to their logistics needs. This trend resulted in a self-examination where we found that logistics processes do not always meet established response time standards. The new DoD goal is to achieve 72 hour delivery by September 1998 (i.e., one-day supply processing and two-day transportation delivery). This is measured from the time of release of a customer order until receipt of an item at an installation in the Continental United States (CONUS) or port of embarkation for outside CONUS.

An area of concern in meeting this response time goal is that its impact is still largely unquantified. Department of Defense decision makers need more defensible estimates of the costs and benefits associated with reducing Logistics Response Time (LRT). Because it represents time that materiel is on order, LRT is symbolically called the customer's pipeline. The primary components of the pipeline are provided in Figure 1-1.

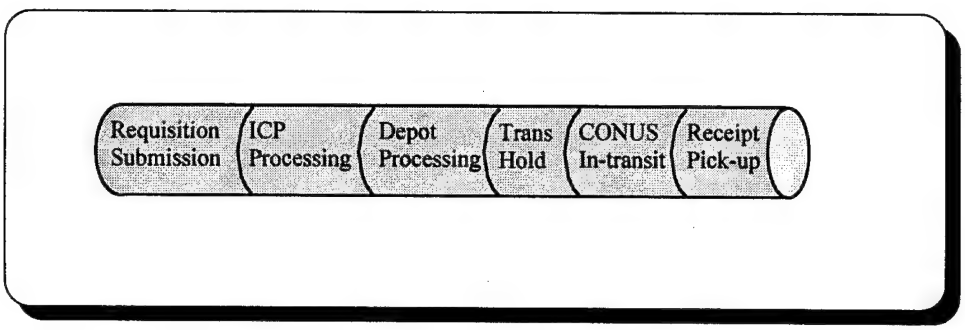

Figure 1-1. A Typical Customer Pipeline

This analytical report assesses the cost implications for DLA, as a wholesale supplier, in reducing the depot processing, transportation hold, and CONUS in-transit segments of this pipeline. Although DLA customers benefit from a compressed pipeline, these benefits are not quantified in this analytical report, but are concurrently being addressed under a study conducted by the Logistics Management Institute (LMI).

SECTION 2
STUDY OVERVIEW

2.1 STUDY DESCRIPTION

This analytical report assesses the cost implications for DLA, as a wholesale supplier, in reducing the depot processing, transportation hold, and CONUS in-transit segments of logistics response time. For these three segments, the clock begins when the cognizant Inventory Control Point (ICP) notifies a distribution depot to issue materiel. Since this requires materiel to be in-stock, backorder time is not covered. The clock ends with carrier delivery at either the customer's location, central receiving point, port, or overseas consolidation point.

There are many approaches that DLA can use to reduce response time. Each approach has its own merits in terms of potential cost implications and response time reductions. In this report, we focus on strategic policy changes in four distinct areas.

1. Reduction in depot processing and transportation hold time. Collectively, we call these segments depot cycle time.

2. Mode of transportation. Current DLA business practices for mode selection can be altered to reduce in-transit time.

3. Geographic alternatives of the new DLA stock positioning policy. This policy area relates to the range of items stocked at distribution depots.

4. Reallocation of inventory to "push" more safety stock to distribution depots co-located with major customer bases. This policy area relates to the depth of stock at co-located distribution depots.

The segments of LRT covered under this report are largely dependent upon the DLA distribution network. Here, there were two major assumptions. First, we assumed that the new DLA stock positioning policy was fully implemented. This policy drives most of the depot workload for DLA materiel to two Primary Distribution Sites (PDS). The remaining depots provide support to customers within a local area and provide specialized storage facilities (for example, hazardous materiel facilities). The second major assumption addressed the DLA distribution network transportation rates. We assumed that the current transportation rates, including Guaranteed Traffic Agreements and commercial rate schedules for estimating second destination transportation costs, would be representative of future rates.

2.2 METHODOLOGY

The comparative basis for our analysis is Fiscal Year 1994 customer demands for DLA materiel, excluding subsistence and fuels. Using the same set of customer demands, we simulated various scenarios represented by reductions in depot consolidation time and changes in the mode of transportation.

A simulation model developed for evaluating these scenarios accepted individual customer demands, or requisitions, as input. For each demand, a shipping depot was determined according to the DLA stock positioning policy and the likelihood of depot stock-outs under that policy configuration. The process for selecting a shipping depot allowed us to evaluate different geographic alternatives of the stock positioning policy (see Appendix A, Section 2) and allocations of wholesale inventory to distribution depots (see Appendix A, Section 3).

Once the shipping depot was determined, the simulation created shipping units by consolidating demands for the same customers at the shipping depot. Routine issues were consolidated by customer Standard Point Location Code (SPLC) and priorities were consolidated by customer Department of Defense Activity Address Code (DODAAC). By varying the depot cycle time, we could assess the impact on materiel consolidations (see Appendix A, Sections 4, 5, and 6).

Finally, shipping units were rated according to Guaranteed Traffic and, when applicable, commercial rate schedules. This process allowed us to investigate the use of alternative transportation modes to reduce in-transit time and speed delivery to the customer (see Appendix A, Sections 7 and 8).

The two key simulation outputs were cost and response time. It is the relationship between these two measures (metrics) that differentiate the geographic alternatives of DLA's stock positioning policy, different allocations of wholesale inventory to distribution depots, variations in depot cycle time, and alternative second destination transportation modes.

2.3 COST METRIC

Costs that were considered are: trans-shipment and receipt costs, incremental depot labor costs, and first and second destination transportation costs (see Appendix A for a detailed treatment of each of these costs). Unless otherwise stated, all costs presented in this report are annual, recurring costs.

For many comparisons made in this report, it is not necessary to address all of these costs. For example, first destination transportation costs and receipt costs are important for a comparison of stock positioning alternatives. However, these costs are not needed to assess alternative second destination transportation modes. For each evaluation presented in this report, only the applicable costs will be discussed.

2.4 RESPONSE TIME METRIC

Response time metrics are depot processing, transportation hold, and in-transit times. They are represented as an average. There are two reasons for using an average measure of response time. First, it is the most commonly used and cited measure. The average is found in reports generated from both the Depot Management Information System and the DLA Logistics Response Time Management File. Second, it is the most commonly used measure of response time for setting retail inventory levels. Retail systems typically look at an expected, or average, wholesale response time when setting reorder points.

2.5 EVALUATIONS

As previously stated, it is cost and response time that differentiates the various alternatives that were simulated. More specifically, it is how the applicable costs change as response time is reduced. This two-dimensional problem is represented by the notional cost curve in Figure 2-1.

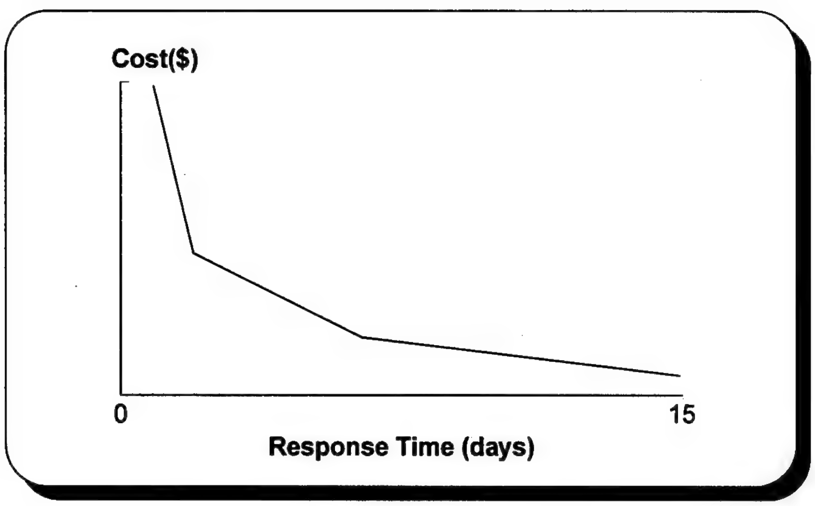

Figure 2-1. Notional Cost Curve

From this graph we can easily see how cost increases as response time decreases. In this report we will assess the rate at which the costs increase for the associated response time reduction.

2.6 REPORT ORGANIZATION

The remainder of this report centers on the following topics:

Section 3, Costs for Time Compression, addresses the cost implications associated with reducing depot cycle time and in-transit time. The time compression scenarios presented in Section 3 are used throughout this report. The baseline configuration of the new DLA stock positioning policy is assumed.

Section 4, Evaluation of Stock Positioning Alternatives, addresses the impact of alternate configurations of the new DLA stock positioning policy. The alternate configurations increase the range of items stored in local support depots. In particular, we will look at how the configuration's cost structure changes as response time is reduced.

Section 5, Evaluation of Changing Wholesale Inventory Allocations, focuses on changing the procedures used for determining site specific inventory levels. We assess the cost and response time benefits associated with achieving increased safety level protection at local support depots.

Section 6, Evaluation of the Use of Dedicated Trucks, provides an indication of the potential gains associated with dedicated truck delivery routes. While not an exhaustive analysis, it does provide the impetus for future analysis of this topic.

Section 7, Evaluation of Time Compression for Selected Item Categories, develops the costs associated with expediting delivery of specific groups of items. This evaluation assumes an automated Issue Priority Group I "up-grade" implementation strategy.

Appendix A, Detailed Methodology, documents our response time modeling methodology, cost development procedures, and data sources. The purpose of this appendix is to give the technical reader a comprehensive treatment of our analytical methodology.

SECTION 3
COSTS FOR TIME COMPRESSION

In this section we develop the costs associated with reducing depot processing and transportation hold time (collectively referred to as depot cycle time) and in-transit time. First, we focused on the implications associated with depot cycle time compression. We did not examine alternative management strategies to obtain reduced depot cycle time. Rather, we concentrated on transportation consolidation impacts and the distribution system's ability to handle daily workload surges. Second, given a fully compressed depot cycle time, we examined the impacts of associated in-transit time compression. Here, we evaluated the use of a different set of business practices for determining the mode of transportation.

3.1 DEPOT CYCLE TIME COMPRESSION

There are two primary costs that are incurred as depot cycle time is reduced. The first is transportation cost. As we reduce cycle time, the time allowed for materiel consolidation for transportation becomes shorter. This results in smaller shipping units. Smaller shipping units are more expensive on a per pound basis to transport. In addition, smaller shipping units may result in changes in transportation mode: more small parcel and Less-Than-Truckload (LTL) shipments. Mode selection for depot cycle time compression is based on current business practices. Generally, priority freight with a destination more than 400 miles away or priority small parcels are shipped by air modes. Priority freight with a destination less than 400 miles away is shipped by surface modes. Truckload (TL) is used for shipping units over 15,000 pounds. LTL is used for shipping units over 150 pounds and less than 15,000 pounds. Small parcel is used for shipping units less than 150 pounds.

The second cost relates to depot labor. Based on Elliott[1], reducing depot cycle time for routine issues to an average of approximately 3.5 days had little impact on direct labor costs. However, the results suggest that further reductions would likely result in increased labor costs. At 3.5 days, depot management still has some flexibility to level or "smooth out" workload surges over time. But when materiel issues are processed within one day, very little "smoothing" can take place. Depots would have to adapt to demand surges by creating an even more flexible workforce, re-assigning personnel, and judiciously using overtime.

Only the amount of overtime was used to estimate the impact on depot labor costs. For convenience, we will call this estimate the incremental depot labor cost. In the development of the incremental depot labor cost estimate (see Appendix A, Section 6), we assumed an optimally sized depot work force. Since the current size of the depot work force may not be appropriate for

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[1] Elliott, R. (1995), Analysis of Depot Test of Cycle Time Reduction. Defense Logistics Agency Operations Research Office, Defense General Supply Center, Richmond, VA.

the workload, incremental depot labor costs, discussed here, may not be additive to today's depot labor costs.

Currently, depot cycle time averages about three days. This represents a significant reduction from cycle times observed one year ago. Given the types of shipments expected under DLA's new stock positioning policy, and a three day depot cycle time, in-transit time would average approximately three days. This average in-transit time is based on current business practices for determining transportation mode. Using these results as a baseline, we simulated reductions in the depot cycle time down to approximately one day. The cycle time reduction scenarios are provided in Table 3-1.

Scenario	IPG I (avg. days)	IPG II (avg. days)	IPG III (avg. days)	Overall Average
Baseline	1.2	1.9	4.0	2.9
1	1.2	1.9	1.9	1.6
2	1.2	1.2	1.2	1.2
3	0.9	0.9	0.9	0.9

Table 3-1. Simulated Depot Cycle Time Scenarios

For each of these scenarios, shipping units were consolidated to the extent possible within the time allotted. In line with current business practices, the size of the shipping unit and the priority of the requisition were used to determine the transportation mode. The net increase, over the baseline scenario, in second destination transportation cost and depot labor cost is provided in Table 3-2.

Depot Cycle Time Scenario	Depot Cycle Time (avg. days)	In-Transit Time (avg. days)	Total Time (avg. days)	Incremental Depot Labor Cost ($M)	Transportation Cost Increase ($M)	Total Cost Increase ($M)
Baseline	2.9	3.0	5.9	0.0	0.0	0.0
1	1.6	3.1	4.7	5.6	2.3	7.9
2	1.2	3.1	4.3	7.1	3.4	10.5
3	0.9	3.1	4.0	8.2	4.2	12.4

Table 3-2. Effect Of Reducing Depot Cycle Time

The results indicate that average response time can be decreased by 1.9 days at a cost of approximately $12.4 million in depot labor and transportation. Depot cycle time reductions mean that less time is available for building consolidated shipping units and, therefore, more materiel is shipped by small parcel and LTL. As a matter of fact, the simulation results also indicated that when the depot cycle time averaged 0.9 days, the number of shipping units was

28% higher than the baseline case. This was the direct result of less consolidation. The slight increase in in-transit time observed for each scenario is the result of more LTL shipments and fewer TL shipments. LTL freight generally moves slower than TL freight (see Appendix A, Section 8).

3.2 IN-TRANSIT TIME COMPRESSION

Generally, reducing in-transit time implies paying for a premium transportation mode. Two drivers can be used on Truckload (TL) shipments to extend delivery routes and reduce in-transit time. Two day air small parcel service can be used to speed delivery of surface small parcel shipments. And, two day air freight service can be used to speed delivery of LTL shipments. In each of these cases, response time will decrease and transportation costs will increase.

Before discussing alternatives for reducing in-transit time, we reviewed the baseline which incorporates current business practices for determining transportation mode. Generally, priority freight with a destination more than 400 miles away are shipped by air modes. Priority freight with a destination less than 400 miles away is shipped by surface modes. TL is used for shipping units over 15,000 pounds. LTL is used for shipping units over 150 pounds and less than 15,000 pounds. Small parcel is used for shipping units weighing less than 150 pounds.

Our analysis focused on three alternatives for reducing in-transit time. Each of these alternatives can be used only in certain situations. The premium transportation alternatives and the decision rules used for applying them are:

1. Dual Drivers. Dual drivers means having two drivers take shifts on long distance hauls. Delivering to a customer 800 miles away using dual drivers can be accomplished with the same in-transit time as delivering to a customer 400 miles away without dual drivers. The use of dual drivers is limited. It only applies to TL shipments with a destination more than 400 miles away.

2. Second Day Air Small Parcel. This transportation mode can be used in place of surface small parcel. However, since surface small parcel deliveries within 450 miles are two days or less, this two day air service only applies to small parcel shipments with a destination more than 450 miles away. This scenario also included using dual drivers where applicable.

3. Second Day Air Freight. Since we have already discussed premium modes for TL and small parcel, this transportation mode was used in place of LTL shipments. It applies to LTL shipments with a destination more than 400 miles away. This scenario also included using dual drivers and second day air small parcel where applicable.

The in-transit time reductions, presented here, assume a fully compressed depot cycle time. In other words, the average depot cycle time will be 0.9 days. For each of these in-transit time reduction alternatives, the net increase over the baseline scenario in second destination

transportation costs and depot labor costs are provided in Table 3-3. For convenience, the baseline cost and response time are re-stated.

In-transit Scenario	Depot Cycle Time (avg. days)	In-Transit Time (avg. days)	Total Time (avg. days)	Incremental Depot Labor Cost ($M)	Transpor-tation Cost Increase ($M)	Total Cost Increase ($M)
Baseline	2.9	3.0	5.9	0.0	0.0	0.0
1	0.9	2.9	3.8	8.2	5.0	13.2
2	0.9	2.8	3.7	8.2	6.0	14.2
3	0.9	1.9	2.8	8.2	31.3	39.5

Table 3-3. Effect Of Reducing In-Transit Time

The results indicate that average response time can be decreased by about three days at a cost of approximately $39.5 million in depot labor and transportation cost. The use of dual drivers and second day air small parcel had little impact on in-transit time reduction. However, incorporating second day air freight instead of LTL produced an in-transit time reduction of almost one day. This one day reduction came with a price tag of approximately $25 million.

The are two features of our distribution system that cause the large increase when using air freight over LTL. First, DLA will be achieving greater consolidation due to the new stock positioning policy. As the PDSs accomplish more of the daily workload, greater consolidation can occur in transportation despite the reduced depot cycle time. Second, LTL has the slowest historical in-transit times of all the transportation modes studied (see Appendix A, Section 8). Therefore by moving this materiel air freight, we are having a more dramatic impact on in-transit time.

3.3 SUMMARY

Depot cycle time compression has a direct impact on second destination transportation costs and depot labor costs. In-transit time reduction has a direct impact on transportation costs. Combining the depot cycle time compression scenarios and the in-transit time compression scenarios presented in this section, the following graph illustrates the annual cost impact of reducing depot cycle time and the corresponding in-transit time.

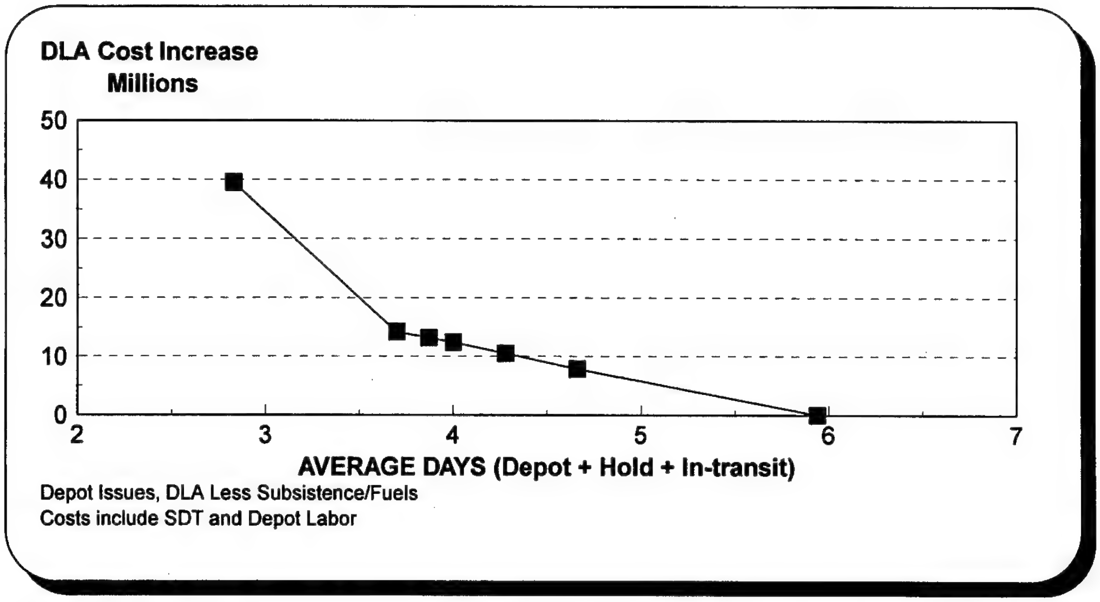

Figure 3-1. Annual Cost Impact Of Reducing Depot Cycle Time And In-Transit Time

SECTION 4
EVALUATION OF STOCK POSITIONING ALTERNATIVES

In this section, we address geographic alternatives of the DLA stock positioning policy with respect to response time and distribution system cost. There are three alternatives within the scope of this effort. The intent of each alternative is to vary the geographic area of support provided by each of the distribution depots. While descriptions of these alternatives can be found in greater detail in Appendix A, Section 2 of this report, the geographic differences are summarized below.

1. Baseline. Under the baseline DLA stock positioning policy, local support depots provide materiel to customers within an approximate 100 mile radius. Customers outside this local support region would receive their materiel from one of the two Primary Distribution Sites. Susquehanna, PA and San Joaquin, CA serve as the two Primary Distribution Sites.

2. Alternative 1. This alternative creates "Oklahoma City, OK and Warner Robins, GA Regionals." This option expands the support regions of Oklahoma City to cover customers in the Midwest and Warner Robins to cover customers in the Southeast. Susquehanna and San Joaquin still operate as the two Primary Distribution Sites. The remaining depots continue to provide support within a radius of 100 miles.

3. Alternative 2. This alternative is one with "Modified 100 Mile Regionals." This option expands the local support regions of Oklahoma City, OK, Warner Robins, GA, Barstow, CA, Jacksonville, FL, and San Diego, CA to cover major customer bases within their geographic areas. Susquehanna and San Joaquin still operate as the two Primary Distribution Sites. The remaining depots continue to provide support within a radius of 100 miles.

When comparing stock positioning alternatives, it is necessary to examine the cost of getting materiel into the DLA distribution system. This includes first destination transportation costs and depot receipt costs. First destination transportation costs are not typically paid directly by DLA. Rather, they are part of the materiel purchase price. We assume that a lower first destination transportation cost for our vendors equates to a corresponding decrease in purchase price. Depot receipt costs are depot costs associated with inspection and induction of materiel into the DLA distribution system. The number of receipts was estimated from the number of stocking depots. If an item is to be stocked at three depots, according to the stock positioning policy, then the receipt cost will be incurred three times for each new procurement.

Other factors that differentiate stock positioning alternatives relate to distribution costs and the time it takes to get materiel from the DLA distribution network into the hands of our customers. These costs include trans-shipment, incremental depot labor, and second destination

transportation costs. The impact of on-base issues and trans-shipments are included in this analysis because they vary according to the stock positioning configuration. Coupled with these distribution costs is the response time. Our comparisons of the three stock positioning alternatives relate to their respective cost behavior as response times decreased. The following three tables, one for the baseline and one for each of the other two stock positioning alternatives, provide a summary of all of the applicable costs as response time decreases.

Total Time (depot and in-transit, avg. days)	First Destination Transportation Costs	Receipt Costs	Trans-Shipment Costs	Incremental Depot Labor Costs	Second Destination Transportation Costs	Total Cost
5.9	54.8	12.9	2.4	0.0	56.0	126.1
4.7	54.8	12.9	2.4	5.6	58.3	134.0
4.3	54.8	12.9	2.4	7.1	59.4	136.6
4.0	54.8	12.9	2.4	8.2	60.2	138.5
3.9	54.8	12.9	2.4	8.2	61.0	139.3
3.7	54.8	12.9	2.4	8.2	62.0	140.3
2.8	54.8	12.9	2.4	8.2	87.3	165.6

Note: All costs in $ Millions

Table 4-1. Annual Costs For Baseline DLA Stock Positioning Policy Under Reduced Response Times

Total Time (depot and in-transit, avg. days)	First Destination Transportation Costs	Receipt Costs	Trans-Shipment Costs	Incremental Depot Labor Costs	Second Destination Transportation Costs	Total Cost
5.8	57.0	15.5	2.6	0.0	56.9	132.0
4.4	57.0	15.5	2.6	5.5	59.4	140.0
4.0	57.0	15.5	2.6	7.1	60.6	142.8
3.8	57.0	15.5	2.6	8.2	61.4	144.7
3.7	57.0	15.5	2.6	8.2	61.9	145.2
3.5	57.0	15.5	2.6	8.2	63.2	146.5
2.9	57.0	15.5	2.6	8.2	90.5	173.8

Note: All costs in $ Millions

Table 4-2. Annual Costs For Oklahoma City And Warner Robins Regionals Configuration Under Reduced Response Times

Total Time (depot and in-transit, avg. days)	First Destination Transpor-tation Costs	Receipt Costs	Trans-Shipment Costs	Incremental Depot Labor Costs	Second Destination Transpor-tation Costs	Total Cost
6.0	54.0	13.9	2.4	0.0	55.7	126.0
4.7	54.0	13.9	2.4	5.4	58.1	133.8
4.2	54.0	13.9	2.4	7.2	59.2	136.7
4.0	54.0	13.9	2.4	8.2	60.1	138.6
3.9	54.0	13.9	2.4	8.2	60.8	139.3
3.7	54.0	13.9	2.4	8.2	61.8	140.3
2.9	54.0	13.9	2.4	8.2	87.0	165.5

Note: All costs in $ Millions

Table 4-3. Annual Costs For Modified 100 Mile Regionals Alternative Configuration Under Reduced Response Times

Note that for each of these tables, seven response times are provided in the left-most column. The costs associated with those response times are all contained in the same row. We assumed that the first destination transportation costs, receipt costs and trans-shipment costs are not significantly impacted by a reduced customer response time. Therefore, these costs remain constant as response time decreases.

Both first destination transportation costs and receipt costs are higher for the Oklahoma City and Warner Robins Regionals alternative. Driving these two costs higher is the number of stock points per item. More stock points means more in-bound shipments and more receipt processing. The average number of stock points per item for each stock positioning configuration is provided below.

Stock Positioning Configuration	Avg. Stock Points per Item
Baseline DLA Stock Positioning Policy	2.05
Oklahoma City and Warner Robins Regionals	2.35
Modified 100 Mile Regionals	2.17

Table 4-4. Average Number Of Stock Points Per Item

A larger number of stock points gives the Oklahoma City and Warner Robins Regionals alternatives a slight advantage in response time. However, this response time advantage comes with a higher system cost. The following graph provides a better comparison of the alternatives as response time decreases.

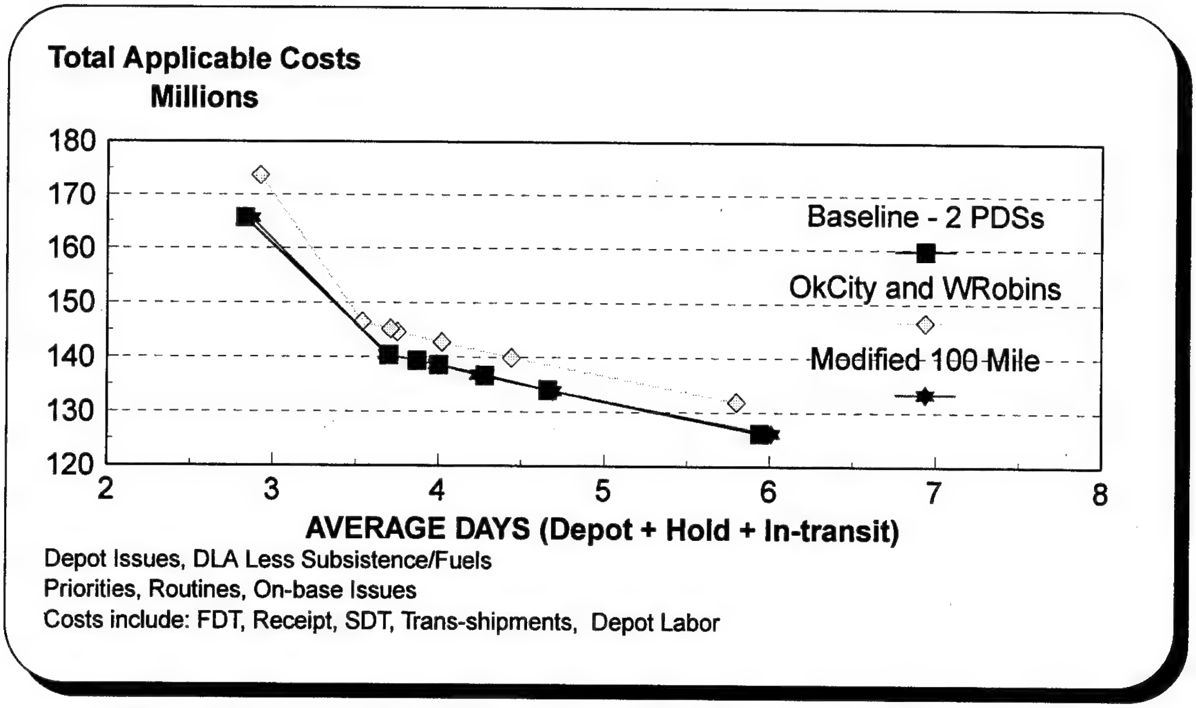

Figure 4-1. Annual Cost For Alternate Stock Positioning Configurations Under Reduced Response Times

As depicted in this graph, both the baseline configuration and the Modified 100 Mile Regional configuration are lower cost solutions at each level of response time simulated.

SUMMARY

The Oklahoma City and Warner Robins Regionals stock positioning alternative yields a greater number of stock points per item. This feature results in greater first destination transportation costs and receipt costs. Both the baseline alternative and the Modified 100 Mile Regional alternative are lower cost solutions at each level of response time simulated. The performance of the Modified 100 Mile Regional alternative suggests that DLA can capitalize on providing tailored support to improve service to selected customers.

SECTION 5
EVALUATION OF CHANGING WHOLESALE INVENTORY ALLOCATIONS

In an idealized distribution system, a customer's materiel will always be available at the closest authorized stocking depot. Materiel can be delivered quicker and the transportation costs will be lower. However, in reality, demand variability creates depot stock-out conditions. Therefore, at the time of the customer demand, materiel may not be available at the closest authorized stocking depot. In these situations the DLA distribution system will not typically backorder the customer's requisition. Rather, the materiel would be shipped from another stocking depot. We call this an out-of-area shipment.

Reducing depot stock-outs, or out-of-area shipments, can be accomplished by raising inventory levels. Of course, increasing inventory levels at all stocking depots runs counter to the whole rationale for reducing logistics response time (as well as the DLA inventory reduction program). One of the issues raised with respect to DLA response time relates to achieving "more optimal" stockage levels at the distribution sites. In other words, should we increase inventory levels at local support depots at the expense of PDS levels? This question makes sense in light of the apparent inequities of depot stock-outs. Table 5-1 highlights the observed percentages of PDS and local support depot stock-outs in our baseline analysis.

Stock-out Location	Percent of Time
PDSs	9
Local Support Depots	20

Table 5-1. Percent Of The Time That A Depot Experiences A Stock-Out

Local support depot demands are not satisfied locally 20 percent of the time. This is over twice the PDS rate. Increasing inventory levels at local support depots would reduce their stock-out rate. By doing this, more materiel would be pre-positioned closer to major customer bases. This would serve two purposes. First, we could protect ourselves from depot stock-outs at these facilities. Second, we could provide back-up support to the PDSs. One drawback is that, unless total DLA inventory levels are increased, we would experience more PDS stock-outs.

The inequities of depot stock-outs by location is not a mystery. Currently, DLA Inventory Control Points compute stockage levels for each stocked item. When an item is procured, it is bought back into stocking depots according to the demand experienced at those depots. This creates distribution system inventory levels that are pro-rated according to site-specific demand rates. The site-specific demand rate is commonly called the Percent Recurring Demand Applicable (PRDA). While this approach may seem logical, a problem is encountered with

safety levels. An important factor in safety level computation is the standard deviation of demand. This factor is not linear with respect to demand. By that, we mean that as demand increases, the standard deviation of demand does not increase at the same rate. The effect of this is that depots with higher demand rates would have better safety level protection than depots with lower demand rates. Since local support depots generally have smaller PRDAs, they get lower safety level protection.

In an effort to determine if local support depots should be allocated a greater percentage of inventory, we needed the cost and response time impact of stock-outs at local support depots, as well as the cost and response time impact of stock-outs at the PDSs. To estimate the costs of stock-outs, we considered second destination transportation costs and trans-shipment costs. Since local support depots operate as central receiving points, a greater number of trans-shipments would occur when local support depots are out-of-stock. With the DLA distribution system achieving a three day response time (see Section 3), the costs associated with each type of stock-out are provided in Table 5-2.

Stock-out Location	Stock-outs resulting in out-of-area shipments	Trans-shipments	Trans-Shipment Costs	Transpor-tation Costs	Total Costs	Cost per stock-out
All	1,694,476	246,246	1,026,846	17,586,674	18,613,520	10.98
PDS	1,051,846	92,022	383,732	13,019,287	13,403,019	12.74
Local Depot	642,630	154,224	643,114	4,567,387	5,210,501	8.11

Table 5-2. Stock-Out Costs Under Three Day System Response Time

In the table above, we can see that the average stock-out, or out-of-area shipment, cost the distribution system about $11. In addition, a PDS stock-out costs approximately $4.50 more than a local support depot stock-out. This result leads us to believe that the current allocation approach used by DLA works well. It reduces the PDS stock-outs at the expense of local support depot stock-outs. Next, we will investigate the response time differences of out-of-area shipments for the PDS and local depot locations.

Stock-out Location	Stock-outs as a Percent of the System Demand	Response Time (depot and in-transit, avg. days)
All	11.8	3.72
PDS	7.3	3.33
Local Depot	4.5	4.35

Table 5-3. Expected Stock-Out Response Time

Depot stock-outs account for less than 12 percent of the system demand. Local support depot stock-outs contribute less than five percent of the system demand. Furthermore, local support depot stock-outs average one day longer than when the stock-out occurs at the PDS. Since local support depot stock-outs represent such a small percentage of system demand, and they average only one day longer, very little improvement can be made in average system response time by simply shifting a greater percentage of assets to the local depots.

SUMMARY

The average cost of a stock-out at a local support depot is $4.50 more than one at a PDS. DLA inventory allocations keep system costs lower by reducing PDS stock-outs at the expense of local support depot stock-outs.

The average response time for a stock-out at a local support depot is one day more than a stock-out at a PDS. However, since local support depot stock-outs represent less than five percent of system demand, little improvement can be made in average system response time. The results indicate that significant gains in average system response time cannot be accomplished by changing the way inventory is allocated to local support depots.

SECTION 6
EVALUATION OF THE USE OF DEDICATED TRUCKS

Under DLA's new stock positioning policy, more materiel will be stored at the two Primary Distribution Sites (PDS). Therefore, materiel will be shipped over greater distances to the customer. A heavy volume of materiel shipped on a weekly basis to a selected customer makes the use of dedicated trucks more economical. In this section we will present our evaluation of the potential for dedicated truck use in terms of lowering response time while reducing cost. This is not an exhaustive analysis of shipping lanes and customer desires. Therefore, we will not make recommendations on specific dedicated truck routes.

Our evaluation of dedicated trucks centered on possible routes originating from Defense Distribution Depot Susquehanna. This depot was selected for two reasons. First, as a PDS it offered a high volume of materiel to many areas east of the Mississippi River. Second, our preliminary analysis of its Guaranteed Traffic Rates suggested that economical conditions exist that would favor dedicated truck routes.

The total weight of materiel shipped from Susquehanna to various customer regions each week was used to select the busiest traffic lanes. Weekly demand profiles for these traffic lanes is provided in Table 6-1.

Destination	Minimum Weekly (pounds)	Average Weekly (pounds)	Number of Weeks Over 15,000 pounds
Ft. Bragg, NC	26,846	123,460	52
Great Lakes Naval Training Center, IL	1,977	87,762	48
Ft. Stewart, GA	5,651	58,304	48
Columbia, SC	862	56,151	46
Ft. Benning, GA	20,733	52,339	52
Ft. Campbell, KY	8,560	49,106	49
Ft. Knox, KY	808	41,007	50
Charleston, SC	6,614	29,342	40
Philadelphia, PA	2,684	26,219	39

Table 6-1. Weekly Demand Profiles To Selected Regions From Susquehanna

We simulated the baseline stock positioning alternative with and without the use of these dedicated truck routes. The following graph provides the increase in second destination transportation costs, with and without dedicated trucks, as response time is reduced.

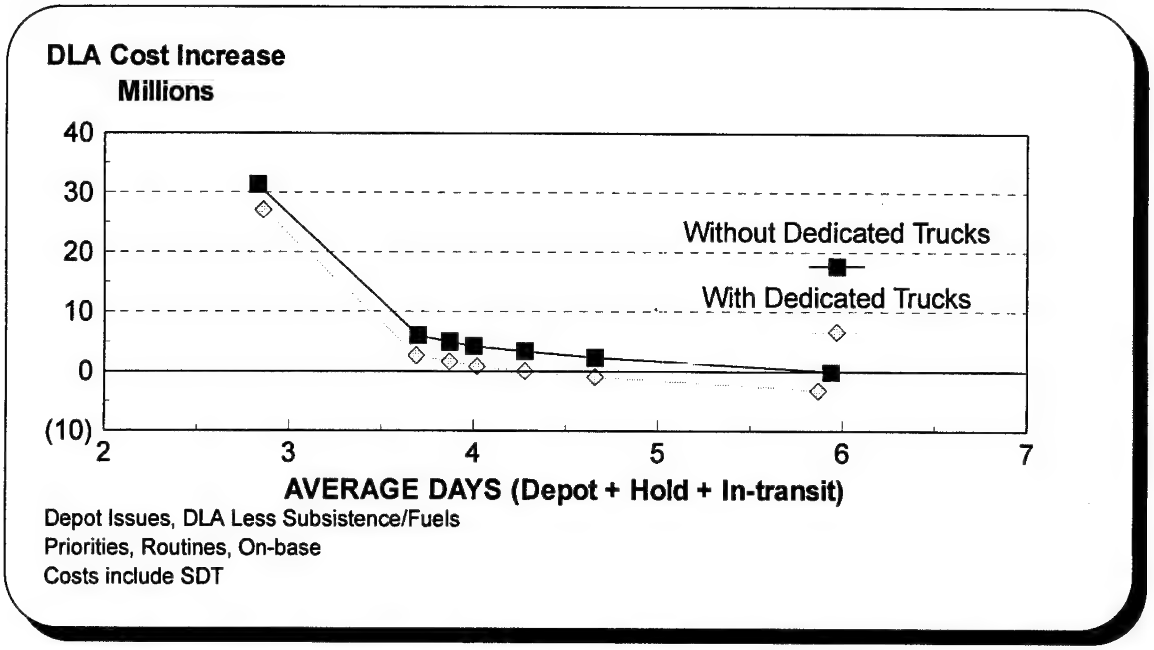

Figure 6-1. Impact Of Selected Dedicated Truck Routes Under Baseline Stock Positioning Policy

As is illustrated in Figure 6-1, the potential cost reductions obtained by using these dedicated truck routes approaches $3 million annually for each level of response time. There are two factors impacting this result. First, priority shipments to the customers that are served by dedicated truck would be staged and consolidated for the next scheduled delivery rather than being shipped by air. Second, the large volume of materiel shipped to dedicated truck destinations makes the dedicated truck route more economical.

Dedicated trucks can significantly reduce DLA second destination transportation costs. This result holds true even as DLA reduces response time. However, despite these advantages, there are many other issues that must be considered before DLA can develop a more comprehensive evaluation of alternate dedicated truck routes. These issues include depot staging capability, added costs for staging materiel, and customer preference. Since we have demonstrated the potential for dedicated trucks in lowering response time while reducing costs, a more comprehensive evaluation is warranted. This can be accomplished when the DLA stock positioning policy nears complete implementation, and traffic lanes are stablized.

SECTION 7
EVALUATION OF TIME COMPRESSION FOR SELECTED ITEM CATEGORIES

One of the taskings of this study effort was to develop the cost of expediting delivery for selected items. Underlying this tasking is the idea that added delivery costs will be small compared to the benefits of reduced retail stock levels. For example, expediting the delivery of a computer circuit board should have a more favorable cost-benefit ratio than expediting the delivery of plate steel. Our efforts to address this issue focused on unit price and unit weight categories.

Unit Price Range	Unit Weight Range (pounds)	Percent of System Demand	Baseline Response Time	Percent Routine
Over $10	Less than 5.0	38.71	5.73	56.24
Over $10	Less than 0.5	16.00	5.38	50.44
Over $50	Less than 5.0	14.80	5.42	50.49
Over $50	Less than 0.5	5.19	5.09	45.31
Over $100	Less than 5.0	8.43	5.11	45.20
Over $100	Less than 0.5	2.89	4.97	43.26
Over $500	Unrestricted	3.07	4.82	39.85
Over $500	Less than 5.0	1.87	4.74	38.40
Over $1000	Unrestricted	1.32	4.71	37.42
Over $1000	Less than 5.0	0.75	4.62	35.69

Table 7-1. Categories Selected For Expedited Delivery Analysis

In Table 7-1, the baseline response time, which includes depot cycle time and in-transit time, represents the average response time for the item category without incorporating any additional management controls. It appears that as the item unit price increases or weight decreases, the response time decreases. This result is primarily due to fewer routine requisitions. For instance, requisitions for items that have a unit price greater than $1000 and a unit weight less than 5 pounds are routine less than 36 percent of the time. Conversely, requisitions for items with a unit price more than $10 and a unit weight less than 5 pounds are routine over 56 percent of the time.

When estimating costs associated with expediting a selected group of items it becomes necessary to assess implementation strategies within the current automated system. In light of this, the simplest implementation strategy is an automatic Issue Priority Group I (IPG I) up-grade. Requisitions for items in a selected group could be up-graded and always processed as an IPG I

requisition. This will increase the transportation costs for IPG I requisitions and decrease the cost for routine requisitions. Since we assumed that the automatic up-grades would be relatively small, the impact on trans-shipments and direct labor would be minimal. This automatic up-grade option was simulated for each of the selected categories of items. Table 7-2 provides second destination transportation cost increases for each category.

Unit Price Range	Unit Weight Range (pounds)	Net Increased Transportation Costs
Over $10	Less than 5.0	13,812,782
Over $10	Less than 0.5	1,486,221
Over $50	Less than 5.0	4,087,661
Over $50	Less than 0.5	515,152
Over $100	Less than 5.0	1,440,120
Over $100	Less than 0.5	299,318
Over $500	Unrestricted	5,165,434
Over $500	Less than 5.0	334,847
Over $1000	Unrestricted	2,916,109
Over $1000	Less than 5.0	183,097

Table 7-2. Costs To Achieve A Three Day Average Response Time For Selected Items

As depicted in Table 7-2, costs associated with an automatic IPG I up-grade vary widely. While not unexpected, this result is driven by the number of issues and weight of the items subject to automatic up-grade. For example, from Table 7-1, we see that items with a unit price more than $500 and a unit weight less than 5 pounds account for 1.87 percent of the system demand and items with a unit price more than $1000 and a unit weight that is unrestricted account for 1.32 percent. From Table 7-2, the costs associated with up-grading the latter of these two groups is approximately nine times that of the former. Clearly, both unit weight and unit price should be addressed to determine when expedited delivery makes economic sense.

SECTION 8
FINDINGS AND RECOMMENDATIONS

Unlike many other efforts to reduce logistics response time, this report addressed response time reductions in areas that are known to have cost implications to wholesale organizations. Many logisticians believe that these added costs will be minimal in light of the potential retail inventory reductions associated with faster wholesale replenishment. In this report, we quantified the costs incurred by DLA as depots reduce requisition bank time, hold time, and in-transit time. Furthermore, we investigated different stock positioning policies relating to range and depth of stock in order to provide reduced response time at the lowest possible cost.

Our analysis indicates that DLA can reduce average system response time for immediate depot issues by two days for an additional annual cost of $12.4 million in depot labor and second destination transportation. The depot labor cost represents overtime required to handle daily workload surges while the transportation cost results from less materiel consolidation time. The additional $12.4 million annual cost would give DLA a four day average response time for issues of any in-stock item anywhere within the Continental United States. With 14.3 million stock issues per year, this equates to 87 cents per issue.

The additional cost to move from a four day to a three day average response time is $25.3 million annually. Driving this result is the increased use of air freight rather than surface Less-Than-Truckload shipments. Expanding the use of dedicated truck deliveries can reduce this cost without significantly impacting response time. DLA would benefit from further analysis on potential delivery routes and stop-offs for dedicated trucks.

To reduce system response time, DLA should not try to increase inventory depth beyond standard distribution site allocations. Furthermore, DLA should not try to significantly increase the geographic support areas for facilities that are not Primary Distribution Sites. Demand variability within a geographic support area, as well as the potential for greater economies of scale, lead us to conclude that the Primary Distribution Sites can make up most response time deficiencies at a lower system cost. Minor enhancements to the geographic configuration of the DLA stock positioning policy, while not a cost nor system response time driver, may provide tailored support to improve DLA's service to selected customers.

APPENDIX A

DETAILED METHODOLOGY

APPENDIX A
DETAILED METHODOLOGY

SECTION A-1: OVERVIEW

This technical appendix details the modeling methodology used throughout the study, documents cost development procedures, and provides data sources.

In Section 2 of this appendix, we discuss the approach used for modeling the new DLA stock positioning policy and the geographic variations under analysis. This approach represents an idealized or perfect policy execution. However, demand is not constant, and therefore policy execution will lead to stock-out conditions and out-of-area shipments. Section 3 covers our treatment of depot stock-outs under this new DLA stock positioning policy.

In Section 4, we present our approach for calculating the depot issue, trans-shipment, and receipt costs. Included in this section is our working definition of situations that lead to on-base issues and trans-shipments. Section 5 covers the treatment of depot processing and transportation hold time. Included in this Section is a discussion of baseline depot cycle time as well as the procedures that were used to model the compression of depot cycle time. Section 6 documents our approach for estimating the labor cost required to achieve a one day depot cycle time standard. These labor costs are based on the expected amount of overtime labor.

Section 7 contains a detailed discussion on how first and second destination transportation costs were determined, and the criteria for using different modes of transportation. Also included in this section is an explanation of the baseline transportation cost estimation procedure. In Section 8, we present in-transit times by transportation mode and a discussion of how they were obtained.

SECTION A-2: STOCK POSITIONING POLICY

A-2.1 BACKGROUND

DLA is currently implementing a new stock positioning policy. This policy serves to accomplish two basic objectives:

1. Pre-position materiel close to major centers of customer demand. This will reduce the amount of time it takes the DLA distribution system to respond to customer's demands.
2. Keep the number of stocking depots per item low. By reducing the number of stock points, DLA can reduce depot receiving workload and achieve economies of scale. A reduced depot workload ultimately reduces the price DLA's customers pay for wholesale materiel.

In an effort to accomplish these objectives, the new DLA stockage policy is composed of two primary components. The first component applies to items that are stocked at locations based entirely on demand. These items are commonly referred to as items that are stocked under the demand-driven stockage policy. The second component applies to items requiring special storage and/or handling facilities. In this case, stock location is driven by the limited number of sites with adequate facilities.

A-2.1.1 Demand-Driven Policy

Under the demand-driven stockage policy, all distribution sites, except the two Primary Distribution Sites (PDS), provide support to customers within a local area (within approximately 100 miles). The local support depot will stock an item if demand in its support region is more than 200 units of issue per year or is more than 5 percent of the system demand. Items failing to satisfy either of these two criteria will be stocked at one or both PDS. Once a stock location is established, the depth of stock at any distribution site is based on the percent of system demand generated within its support region.

A-2.1.2 Special Facility Requirements

Due to their specialized nature, items requiring special storage and/or handling facilities do not fall under the purview of the demand-driven policy. These items require special care that is not available at all distribution sites. Like the demand-driven stockage policy, the depth of stock at any distribution site is based on the percent of system demand generated within its support region. However, unlike the demand-driven stockage policy, stocking depots provide regional support. For example, New Cumberland and Sharpe are the only locations that have the facilities required for low-level radioactive items. This means that New Cumberland will provide support to all customers east of the Mississippi River and Sharpe will provide support to all customers

west of the Mississippi River. The major categories of special items and their authorized stocking locations are supplied in Table A-1.

CATEGORY	LOCATION(S)	IDENTIFICATION
Classified	all EXCEPT Susquehanna, Norfolk, Jacksonville, Albany	PSC=(A,B,C,D,E,F,G,H,K,L,O,S,T,7,9) or PSC=(J,I,M,N,P,Q,R,V,W,X,Y,Z)
Magnetic Storage	San Joaquin	HCC=M1
Shelf Life Items	Susquehanna, San Joaquin	SLC=anything but 0
Asbestos	New Cumberland	SRC=D and HCC=T6
Radioactive (low)	New Cumberland, Sharpe	SRC=A and HCC=A_
Compressed Gas	Richmond	SRC=L and HCC=G_
Medical Hazardous	Richmond, San Joaquin	ICP=M and HCC=non-blank
Other Hazardous	Richmond, San Joaquin	HCC=(C_, D_, E_, F_, J_, K_, P_, R_, T_, W_)
Pipe / Bulk Steel	Susquehanna, San Joaquin	FSC=(1560,5970,5975,4410,4710,6145,9505,9510, 9515,9520,9525,9530,9535,9545,9650) and (Unit cube > 0.5 or Unit weight > 10 or Unit issue=(pound, foot, length, plate, sheet))
Government Furnished Materiel	Albany	ICP=T and MCC=(H, E)
Deployable Medical System Items	Hill, Mechanicsburg	FSC=6545

PSC(Physical Security Code) HCC(Hazard Characteristic Code) SLC(Shelf Life Code)
SRC(Special Requirements Code) ICP(Inventory Control Point) FSC(Federal Stock Class)
MCC(Method of Computation Code)

Table A-1. Location And Identification Of Items Requiring Special Storage

A-2.2 METHODOLOGY

Since this latest policy is currently being implemented, limited data exists regarding where items will ultimately be stocked. This section briefly describes how we overcame this limitation in an effort to capture the impact of the DLA stock positioning policy.

A-2.2.1 Demand-Driven Policy

Items not having special facility requirements were assumed to fall under the demand-driven component of the policy. Stock locations for these items were determined by analyzing historical demand by item and geographic customer location. When the demand-driven criteria for stockage were satisfied under the historical demand, we assumed that the item would be stocked at that facility.

A-2.2.2 Special Facility Requirements

Items having special storage requirements were identified and assumed to be stocked only at locations with adequate facilities. The identification process involved examining multiple item characteristics. These characteristics are depicted in Table A-1.

A-2.3 ALTERNATIVES

When attempting to reduce the transportation segment of logistics response time, the geographic location of stock becomes more important.

A-2.3.1 Baseline Alternative

Under the baseline DLA stock positioning policy, local support depots provide materiel to customers within an approximate 100 mile radius. Customers outside this local support region receive their materiel from a PDS. Figure A-1, which uses the two-digit Routing Indentifier Code (RIC) to differentiate distribution sites, illustrates the geographic support regions of this policy.

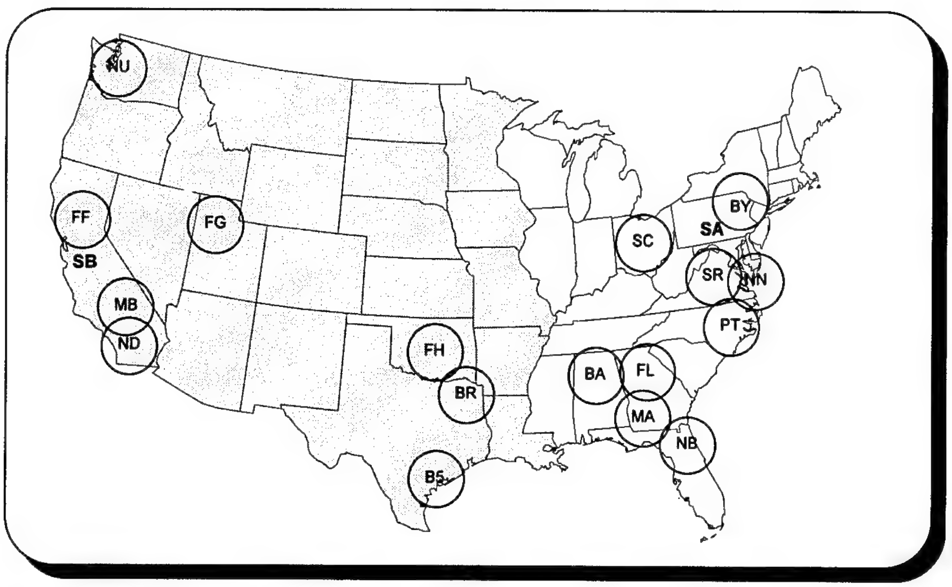

Figure A-1. Geographic Configuration Of The DLA Stock Positioning Policy

A major issue facing DLA management under compressed customer order-ship times is whether to push more materiel out to local support depots by expanding the local support area or expediting delivery from a PDS. By expanding local support areas, the number of stock points per item will increase. As the number of stock points increases, so does new procurement receipt costs. On the other hand, expediting delivery from a PDS will also increase costs. In an effort to evaluate this issue DLA has formulated two alternatives.

A-2.3.2 Alternative: Oklahoma City and Warner Robins Regionals

This alternative creates "Oklahoma City and Warner Robins Regionals." This option expands the support regions of Oklahoma City to cover customers in the Midwest and Warner Robins to cover customers in the Southeast. Susquehanna and San Joaquin still operate as the two Primary Distribution Sites. The remaining depots continue to provide local support within a 100 mile radius. Figure A-2 illustrates the geographic support regions of this alternate policy.

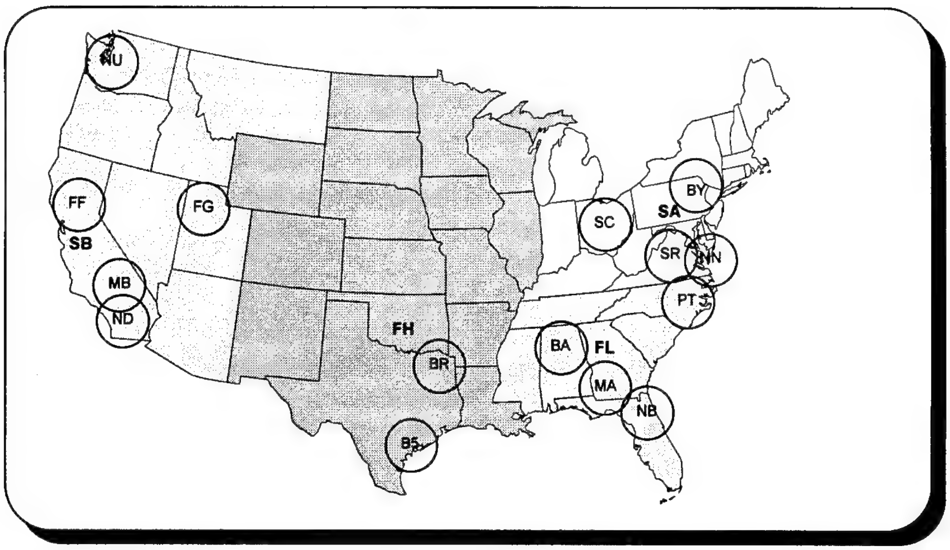

Figure A-2. Geographic Configuration Of The DLA Stock Positioning Policy Oklahoma City/Warner Robins Regionals

A-2.3.3 Alternative: Modified 100 Mile Regionals

This alternative is one with "Modified 100 Mile Regionals." This option expands the local support regions of Oklahoma City, Warner Robins, Barstow, Jacksonville, and San Diego to cover major customer bases within their geographic areas. Susquehanna and San Joaquin still operate as the two Primary Distribution Sites. The remaining depots continue to provide local support within a 100 mile radius. Figure A-3 illustrates the geographic support regions of this alternate policy.

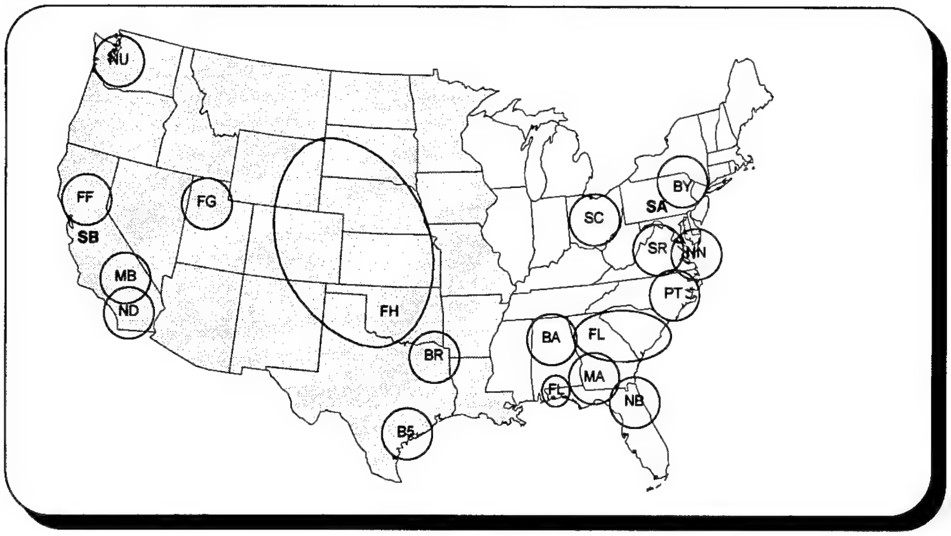

Figure A-3. Geographic Configuration Of The DLA Stock Positioning Policy Modified 100 Mile Regionals

SECTION A-3: PROBABILITY OF SATISFACTION OF DEMAND FROM THE PREFERRED DEPOT

A-3.1 BACKGROUND

When the depot closest to the customer is out-of-stock for an item and the materiel is available at another depot, any demand from that customer for that item would have to be shipped from a depot farther away. This would increase both response time and transportation costs. We call the customer's closest stocking depot a preferred depot. A customer's preferred depot varies by item. For an item that is only stocked in Susquehanna, the preferred depot for all customers is Susquehanna. For an item that is stocked in San Joaquin and Susquehanna, the preferred depot is San Joaquin for all customers west of the Mississippi River and Susquehanna for all customers east of the Mississippi River.

Historical information on preferred depot shipments is not yet available for the new DLA stock positioning policy. Furthermore, the new stock positioning policy will not prevent depots from experiencing stock-out conditions and shipments from non-preferred sites. Two relevant facts that lead to non-preferred depot shipments are described next.

1. Replenishment stock is ordered when the system asset position falls below the system reorder point. Because of demand variability, some depots may be out-of-stock before the order point is breached while others have an abundance. It is the total assets on-hand that is used to determine when the next replenishment order occurs.

2. The replenishment stock will arrive at the depots a lead-time, typically 250 days, after the materiel is ordered. Again, because of demand variability some depots may experience out-of-stock conditions during the time it takes to replenish. Meanwhile, others may have an abundance.

In an effort to quantify the impact of depot out-of-stock conditions, this section describes the development of the probability that a demand will be satisfied by the preferred depot (i.e. the closest stocking depot).

A-3.2 METHODOLOGY AND ANALYSIS

Consistent with the work of Kaplan[2] a simulation was developed to track depot stock-outs for 152,000 items managed by the Defense General Supply Center. To track depot stock-outs, the simulation had to monitor on-hand inventory at each depot. The following processes were simulated:

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[2] Kaplan, A. (1972), Performance Standards for Depot Initial Fill Rates. Inventory Research Office, U.S. Army Logistics Management Center, Fort Lee, VA.

1. Receipt of demand. Demands were generated from each stocking depot region using a random number generator for Compound Poisson demand (Exponential interarrival times and Geometric requisition sizes). The parameters of the distributions were estimated from historical demand rates.

2. Selection of the depot to fill the demand. First, the preferred depot was checked for assets on-hand, then the Primary Distribution Site on the same side of the Mississippi River as the preferred depot, the other distribution sites on the same side of the Mississippi River, the PDS on the opposite side, and finally the other distribution sites on the opposite side. No efforts were made to avoid split shipments.

3. Establishment of backorders. Backorders occurred when assets could not be found at any site and were held until assets became available.

4. Determination of when and how much replenishment stock to reorder. Replenishment stock was reordered when the item's asset position (stock on-hand + stock due-in from procurement - stock backordered) was less than the reorder point (lead-time demand + safety level). The amount of materiel ordered was the item's economic order quantity plus any deficit below the reorder point.

5. Allocation of replenishment stock to stocking depots. Replenishment stock was allocated to the stocking depots according to the percent of total demand historically experienced within each depot's support region. In DLA, this is commonly referred to as the Percent Recurring Demand Applicable (PRDA).

6. Receipt of replenishment stock at the stocking depots. Replenishment stock was received a lead-time after it was ordered.

7. Fulfillment of any outstanding backorders. Backorders were filled according to the same search criteria used to satisfy initial demands.

To start the simulation, we computed or obtained each item's economic order quantity, safety level, lead-time, procurement cycle, average lead-time demand, average requisition size, and number of stocking depots. For each of the item's stocking depots, we computed the PRDAs using historical demands from the depot's support region. Each of these item characteristics were held constant throughout the simulation.

The simulator tracked, by NSN, the number of demands within each stocking depot's support region, the number of times the preferred depot could not satisfy the demand, and the number of backorders. Supply Availability by depot and for the system were computed as:

$$SA(depot) = 1 - \frac{\text{Number of inital demands not satisfied by the perferred depot}}{\text{Number of demands from perferred depot support region}} \text{ and}$$

$$SA(system) = 1 - \frac{\text{Number of backorders}}{\text{Number of demands from all regions}}.$$

Our objective is to capture only those situations when the initial demand was filled by the non-preferred depot. In other words, given that assets exist in the distribution system, the probability that a demand will be satisfied at the preferred depot, or the distribution effectiveness, can be computed as

$$SA(depot|system) = \frac{SA(depot)}{SA(system)}.$$

This measure quantifies the goal of having the right amount of materiel at the right location at the right time. Kaplan identified four key variables that significantly impact distribution system effectiveness (note that Kaplan measured effectiveness from a distribution *system* perspective and we are trying to develop an analogous measure at the distribution *site* level). These variables are:

1. Coefficient of variation of lead-time demand. Based on the Compound Poisson assumption, the coefficient of variation is given by Kaplan as $C = \sqrt{\frac{2S-1}{D}}$, where S is the average requisition size and D is the lead-time demand quantity. As the coefficient of variation decreases, distribution effectiveness increases.

2. Distribution of demand. This represents the percent of system demand, or PRDA, that is generated within a stocking depot's servicing region. As the PRDA for one site increases and the system becomes more asymmetrical, distribution effectiveness increases.

3. Number of stocking depots. As the number of stocking depots decreases, distribution effectiveness increases.

4. System supply availability target. As the system supply availability increases, distribution effectiveness increases.

Using these four variables as grouping factors, we summarized the simulation output. Table A-2 provides the groupings for each variable.

Coef. Var.	PRDA(%)	# Depots	Sup. Avail.
0.00-0.20	0-20	2	%0-49
0.21-0.40	21-40	3	50-69
0.41-0.60	41-60	4	70-79
0.61 and up	61-80	5	80-89
	81-100	6 or more	90-94
			95-100

Table A-2. Groupings For Key Variables

From the simulation output, we computed the average distribution effectiveness for each combination of grouping levels. These averages were then used in a regression model. The

results of this regression model produced an $R^2 = 0.88$. The parameter estimates are contained in Table A-3.

R-square = 0.880	Intercept	Coef. Var.	PRDA	# Depots	Sup. Avail.
Parameter Estimate	0.636	-0.219	0.249	-0.014	0.305
Standard Error	0.012	0.006	0.008	0.002	0.011

Table A-3. Results Of Regression On Key Variables

Using these regression estimates, the probability that the preferred depot will be able to satisfy a non-backordered demand is given by the following equation

$$0.636 - 0.219(\text{Coef. Var.}) + 0.249(\text{PRDA}) - 0.014(\text{\# Depots}) + 0.305(\text{Sup. Avail.}).$$

A-3.3 USAGE CONSIDERATIONS

The nature of the grouping levels underlying the regression model limited the influence of extreme values. For example, all items with more than six stocking depots were treated as one group for the number of depots variable. This permitted a better linear fit in the grouping level regions that are most prevalent under current inventory management policies. The maximum coefficient of variation used in the regression model was 2.0. This maximum was obtained when the PRDA was between 0% and 20% and the coefficient of variation was 0.61 and up. The maximum number of stocking depots used in the regression model was six and the minimum was two (obviously for the case of one stocking depot, 100% of the demand will be satisfied by that depot). These constraints on the coefficient of variation and the number of depots will be applied when using the equation above.

In addition to these constraints on the independent variables, the solution will be truncated at 1.0. The minimum solution will not be less than the observed minimum solution of 0.3. This minimum occurred when the PRDA was between 0% and 20%, the coefficient of variation was 0.61 and up, the number of depots was 6 or more, and supply availability was less than 69%.

A-3.4 CONCLUSIONS

Having the right amount of stock at the right location at the right time is a difficult task. Even with the best possible stock positioning policy, shipments of materiel by non-preferred depots will exist. Shipments by preferred depots will take less time at a lower cost than shipments by non-preferred depots. Of course, satisfaction of demand by non-preferred depots is still more responsive to the customer than a backorder.

To capture the extra time and cost of these non-preferred depot shipments, we developed the probability that a demand will be satisfied by the preferred depot. This probability is a function of the coefficient of variation of lead-time demand, the PRDA, the number of stocking depots, and the supply availability target.

SECTION A-4: ISSUES, TRANS-SHIPMENTS AND RECEIPTS

A-4.1 BACKGROUND

The development of distribution depot processing costs has become more complex since DLA assumed management of some of the traditional Military Service depots. In addition to classifying workload in terms of heavy bulk, medium bulk, binnable, and hazardous issues, DLA also has to be concerned with on-base and off-base issues and trans-shipments.

Another compounding factor is the Defense Business Operation Fund (DBOF) rate structure. Under DBOF, DLA seeks to be fully reimbursable for their logistics services. For example, a distribution depot balances its cost of operation against its workload mix. The workload mix is primarily composed of on-base and off-base issues, receipts, and trans-shipments. Issues and receipts are classified as heavy bulk, medium bulk, binnable, and hazardous. By using these different categories of workload, DLA distribution depots are able to develop more equitable charges to the Inventory Control Points for their services. The Fiscal Year 1995 distribution DBOF rate structure, which incorporates second destination transportation costs, is provided in Table A-4.

	Receipts	On-base Issues	Off-base Issues
Binnable	$18.55	$9.56	$14.29
Medium Bulk	22.86	18.49	27.99
Heavy Bulk / Hazardous	46.19	42.65	67.51
Trans-shipments		4.17	

Table A-4. Fiscal Year 1995 Distribution DBOF Rate Structure

A-4.2 ISSUE AND TRANS-SHIPMENT COSTS

Depot issue costs are not included in this study. We assumed that the number of issues would not change with reduced response time nor with an alternative to the DLA stock positioning policy. Furthermore, we assumed that the cost of an on-base issue was the same as the cost of an off-base issue, after transportation costs are excluded. All trans-shipments were assessed the same cost, $4.17.

A-4.3 ISSUE AND TRANS-SHIPMENT IDENTIFICATION

The differences between on-base and off-base issues are important in estimating response time, particularly in-transit time. Therefore, we need to determine the situations that lead to on-base

and off-base issues. In addition, we need to determine the situations that lead to trans-shipments in order to appropriately apply the trans-shipment cost.

The determination of situations that lead to on-base issues, off-base issues, and trans-shipments depends on the geographic location of the customer with respect to the issuing depot, the priority of the customer's requisition, and whether or not the customer is co-located with any other distribution depot operating as a central receiving point. These criteria are illustrated in Figure A-4.

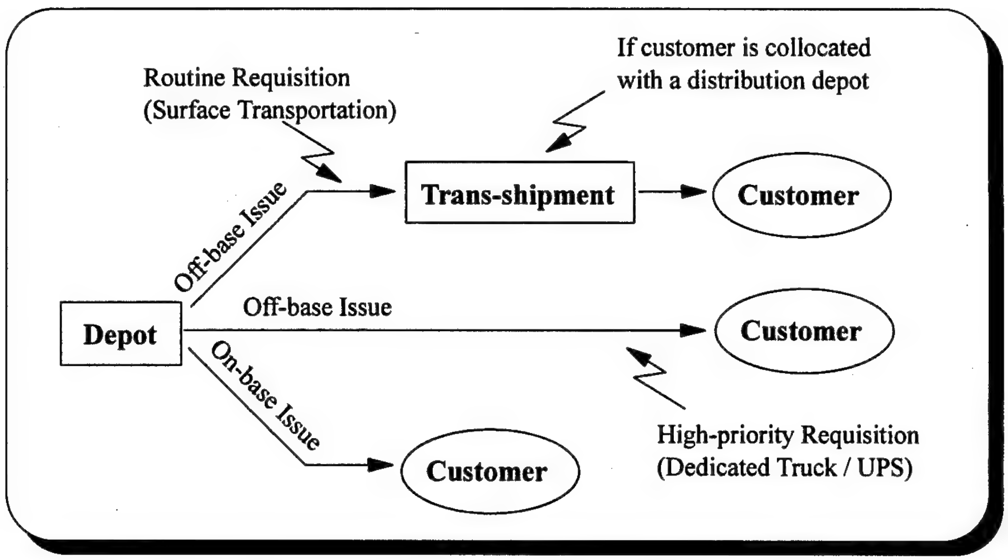

Figure A-4. Distribution Depot Issue Processing

To satisfy a routine requisition for an off-base customer, materiel will typically travel via surface transportation under a Government Bill of Lading (GBL). The freight will arrive at the customer's central receiving point. If the central receiving point is another distribution depot, a trans-shipment charge is incurred by the DLA distribution system. However, high-priority requisitions for off-base customers are not typically handled by central receiving. Therefore, trans-shipment charges would not apply. The shipper, for example United Parcel Service (UPS), will deliver directly to the customer.

When the requisitioner is co-located with the issuing distribution depot, an on-base issue occurs. While on-base issues are treated differently under the OSD guidance on reducing logistics response time, they must be incorporated into our analysis. The primary reason for this is because we are evaluating different geographic configurations under the new DLA stock positioning policy. One of the drivers behind this policy is to pre-position materiel close to customers and in many instances, such as at Defense Distribution Depot Norfolk Virginia (DDNV), a major DLA customer base happens to be co-located. Therefore, in order to capture benefits of the new stock positioning policy, and to differentiate the geographic alternatives, we must consider on-base and off-base issue response times.

A-4.4 RECEIPT METHODOLOGY

In developing the cost to process a materiel receipt, we utilized the 1995 DBOF Rate Structure. By using receipt workload counts from the Depot Management Information System, we computed the percentage of receiving workload that is binnable, medium bulk, heavy bulk, and hazardous for each ICP. The depot receiving cost can then be computed according to each ICP's item mix. DLA receiving workload and percentages (in shaded regions) are supplied in Table A-5.

DLA ICP	Binnable	Medium Bulk	Heavy Bulk/ Hazardous	Totals
Construction	99,246	46,264	6,082	151,592
	65.47	30.52	4.01	100.00
Electronics	111,579	19,985	718	132,282
	84.35	15.11	0.54	100.00
General	61,145	25,889	7,696	94,730
	64.55	27.33	8.12	100.00
Industrial	106,597	29,573	3,548	139,718
	76.29	21.17	2.54	100.00
Medical	8,563	11,498	621	20,682
	41.40	55.59	3.00	100.00
Textiles	8,486	21,854	4,027	34,367
	24.69	63.59	11.72	100.00

Table A-5. Receiving Workload Percentages (Oct 94 - Feb 95)

For example, Construction items generate depot receipts that are 65.47 percent binnable, 30.52 percent medium bulk, and 4.01 percent heavy bulk/hazardous. These workload mix percentages can then be used to arrive at the expected receipt cost for each receipt for a Construction item.

SECTION A-5: DEPOT PROCESSING AND TRANSPORTATION HOLD TIMES (DEPOT CYCLE TIME)

A-5.1 BACKGROUND

Depot processing and transportation hold time, or depot cycle time, is that time segment that starts when the cognizant Inventory Control Point produces a Materiel Release Order (MRO) and ends when the materiel is shipped. Processes that occur during this time segment may include banking MROs prior to picking, picking and packing, and holding the packed materiel prior to shipping. The banking and holding operations serve as consolidation points. Generally longer banking and/or holding times result in more consolidation and larger shipping units. Larger shipping units, of course, result in lower transportation costs.

A-5.2 METHODOLOGY

Depot processing and transportation hold operations vary by depot. These differences are primarily due to different management philosophies, different automated systems, and different levels of workload. While some differences will inevitably exist at distribution sites, three fundamental changes will have an impact on the future operations of defense distribution sites.

1. DLA has recently assumed management responsibility for all distribution depots. By not having military service and DLA managed sites, we may see greater standardization in depot operations.

2. The Depot Standard System is currently being implemented to replace each service's legacy system. By not having both military service and DLA automated systems, we may see standardization in depot operations.

3. DLA has recently implemented a new stock positioning policy. This new policy will push more workload to the two Primary Distribution Sites (PDS). The large volume of workload at the PDS may necessitate more flexibility in depot operations.

Given these fundamental changes in today's fluid environment, establishing a good baseline depot cycle time is difficult. However, we do know that the amount of consolidation is typically controlled by management using a maximum bank or hold time. This implies that all MROs arriving at the depot within the same time window would be consolidated by customer location for shipment. To estimate the total depot consolidation time window, we focused on the 95th percentile of MRO hold time. The following table provides information from the DLA Logistics Response Time Management File on depot shipments of DLA materiel for March 1995, on the average and 95th percentiles for each Issue Priority Group (IPG).

IPG	Average (days)	95th Percentile (days)
I	1.2	4
II	1.9	6
III	4.0	10

Table A-6. Baseline Depot Cycle Time Statistics

The 95th percentile was used as the maximum consolidation time. Our approach for modeling the impact of reducing depot cycle time was to reduce this maximum consolidation time. The reduction in the maximum consolidation time reduces both the average and the variance of depot cycle time.

SECTION A-6: INCREMENTAL DEPOT LABOR COSTS

This section explains the methodology used to develop incremental depot labor costs. Incremental depot labor costs represent the overtime required to handle daily workload surges. To estimate overtime costs, we need to know the number of issues processed during overtime periods and the direct labor cost to process an overtime issue.

A-6.1 ISSUES PROCESSED DURING OVERTIME PERIODS

The number of issues processed during overtime periods is simply the difference between the number that must be processed each day and the number that can be processed during regular time. The number processed during regular time depends on the depot staffing level. Depot work forces are based on the expected yearly workload. Since a change in stock positioning policy may increase the Primary Distribution Sites (PDSs) workload while decreasing the local support depot workload, future staffing levels will not be the same as today's levels. While it is beyond the scope of this study to make future depot staffing level recommendations, we did perform a limited workload analysis to estimate the number of overtime issues.

We assigned Fiscal Year 1994 (FY94) requisitions to distribution depots according to the new DLA stock positioning policy. The daily workload for one of the PDSs is shown in Figure A-5 below.

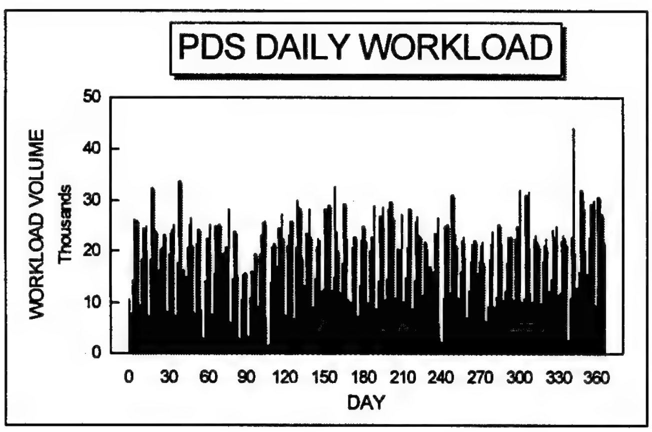

Figure A-5. Daily Issue Workload

This graph shows the FY calendar day on the horizontal axis and the daily workload volume on the vertical axis. Workload is defined as the number of requisitions the depot receives from the Inventory Control Point (ICP) on a given day. Low points on the graph correspond to weekends and holidays. Since depots have historically received and processed only high priority

requisitions on weekends and holidays, these days were not included in the workload analysis to estimate the depot staffing levels.

To illustrate and explain the methodology for setting the depot staffing level, Figure A-6 shows a PDS daily workload for a 32 day period. Note that weekends and holidays have been excluded, and that workload volume ranges between 10,000 lines per day to over 26,000 lines per day.

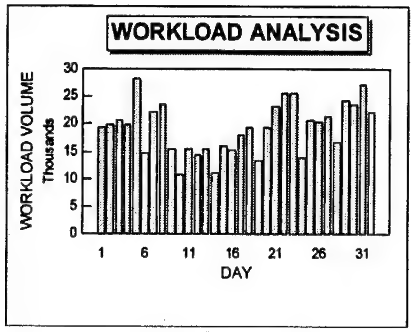

Figure A-6. Daily Issue Workload For A 32 Day Period

Now suppose that the PDS is staffed to handle a production rate of 15,000 lines per day, 20,000 lines per day, or 25,000 lines per day. Figure A-7 shows graphically the impact of each of these production staffing levels. The variation in daily workload will cause days to have excess staffing levels and other days to have deficient staffing levels. For example, if the staffing level is set at 20,000 lines per day, when less than 20,000 requisitions are received the staffing level will be in excess, and when more than 20,000 requisitions are received the staffing level will be deficient.

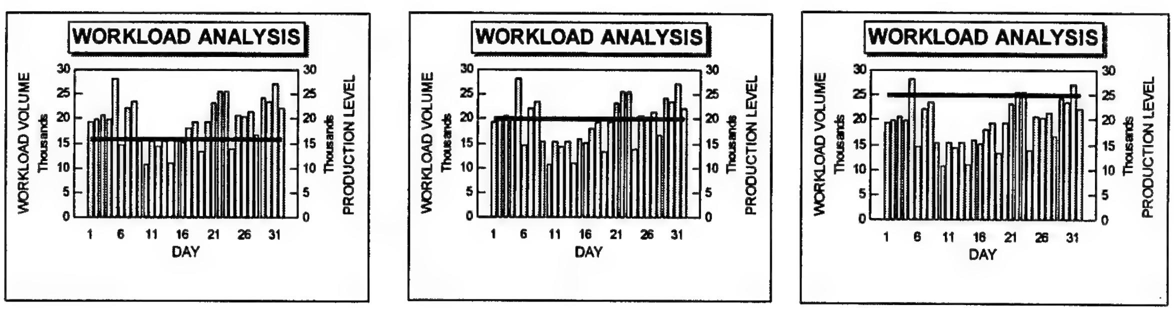

Figure A-7. Effect Of Different Staffing Levels

When the staffing level increases, the amount of deficient lines will decrease and the amount of excess lines will increase. Table A-7 summarizes the number of excess and deficient lines over the 32 day period.

Staffing Level	Excess Lines	Deficient Lines
15,000 Lines per Day	12,677	148,971
20,000 Lines per Day	72,604	48,898
25,000 Lines per Day	190,269	6,563

Table A-7. Excess And Deficient Lines By Staffing Level

There is a trade-off between excess lines and deficient lines. The trade-off was determined by using the total cost concept. First, we selected various staffing levels for test based on workload percentiles. Percentiles indicate the percentage of time that the number of daily requisitions is equal to or below a particular level. For example, if the 60th percentile level was 43,000 lines then 60 percent of the time 43,000 lines or less are received at the depots on a given day. Second, we summed the excess lines and deficient lines for the year based on each staffing level tested. The deficient lines were weighted by 1.5 since overtime would be necessary to process all requisitions in one day. The sum of excess lines and deficient lines gives a total "cost" curve. The least "cost" of this curve estimates the depot staffing level. The system total cost curve, combining all DLA depots, is provided in Figure A-8.

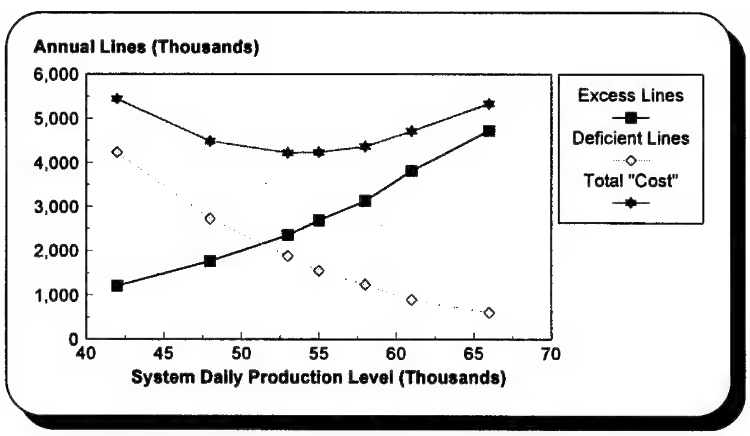

Figure A-8. System Total Cost Curve

The minimum point on the total "cost" curve corresponds to the 70th percentile level of daily workload. Using this result, we assumed that the distribution depots were staffed to handle the 70th percentile of daily workload and determined the number of regular time lines that could be processed in one day. By subtracting the workload received each day by the number of regular time lines, we obtained the number of lines that must be accomplished during overtime periods.

A-6.2 COST TO PROCESS AN OVERTIME ISSUE

The cost to process an issue during overtime is a marginal, or direct labor, cost. This prevents us from using the DBOF cost recovery rates. Recently, Sims[3] developed direct labor costs as part of a research effort to estimate the costs and benefits of DLA's new stock positioning policy. They provided direct labor costs per line broken out by binnable, bulk, and hazardous. To derive an expected cost per line, we obtained workload percentages by type from the Depot Management Information System. Table A-8 shows the direct labor cost and the percentage of each type of issue.

Direct Labor Cost Area	Cost per Line PDS	Cost Per Line Non-PDS	Percent of Lines
Binnable	3.44	6.00	65.97
Bulk	10.31	10.31	31.48
Hazardous	15.28	15.28	2.55
TOTAL			100.00

Table A-8. Direct Labor Costs

The cost difference between a non-PDS and a PDS line is in the binnable area. PDSs have an economy of scale and can process binnable requisitions at a lower cost than non-PDSs. By weighting the direct costs per line by the appropriate percentage, the expected direct labor cost for a non-PDS depot is $7.59 and for a PDS is $5.90. Therefore, PDS overtime cost is $8.85 ($5.90 times 1.5) and the non-PDS overtime cost is $11.39 ($7.59 times 1.5).

A-6.3 COST SUMMARY

Once a staffing level is set, then the number of overtime lines required to achieve a one day standard can be calculated. By multiplying the number of overtime lines by the cost per line, we obtained the annual incremental depot labor costs. These costs are provided in Table A-9 for four different staffing levels.

3 Sims, R. and G. Armstrong (to be published), Distribution and Cost Analysis for New Stock Positioning Policy. Synergy, Inc., Washington, DC.

Staffing Level Percentile	Annual Overtime Cost (Millions)
60	$11.9
70	$8.2
80	$5.4
90	$2.7

Table A-9. Annual Incremental Depot Labor Costs By Staffing Level

Based on the estimated staffing level set at the 70th percentile, the annual overtime cost is $8.2 million.

SECTION A-7: TRANSPORTATION COSTS

A-7.1 BACKGROUND

Throughout the DLA distribution network, Guaranteed Traffic (GT) agreements form the basis for determining transportation costs. However in some instances, particularly for small parcel shipments, these agreements are not used by the Transportation Officer (TO). Rather, the TO arranges for commercial carriers to deliver materiel. These arrangements depend upon the nature of the cargo, source and destination, priority requirements, and transportation cost. We similarly used these criteria to determine the mode of transportation for estimating transportation costs.

A-7.2 METHODOLOGY

Transportation costs were developed using a combination of GT rates and published carrier rates. Listed below are different transportation modes and the source of the transportation rates.

1. Surface Freight. Surface freight transportation rates were obtained from current GT agreements. These rates applied to shipping units greater than 150 pounds and vary according to shipping depot, destination, and cargo weight.

2. Surface Small Parcel. Surface small parcel transportation rates were obtained from UPS published rates. These rates applied to shipping units less than or equal to 150 pounds and vary according to parcel post zone and package weight.

3. Air Freight (2-day service). Air freight transportation rates were obtained from the most recent GT agreements for second day service. While these agreements are not currently in effect, they provided the best information available for rating air freight in different geographic regions. As with surface freight rates, these rates applied to shipping units greater than 150 pounds and vary according to shipping depot, destination, and cargo weight.

4. Air Freight (1-day service). Since air freight rate tables for 1-day service were unavailable for this study effort, we relied on an analysis of the Freight Information File (FINS). This analysis revealed that 1-day air freight delivery cost an average of 27.64% more than 2-day delivery. This cost factor was applied to the 2-day air freight rates to obtain 1-day air-freight rates.

5. Air Small Parcel (1-day service). Air small parcel transportation rates were obtained from GSA rate tables. These rates applied to shipping units less than or equal to 150 pounds and vary according to package weight.

6. Air Small Parcel (2-day service). Since air small parcel rate tables for 2-day service were unavailable for this study effort, we again relied on an analysis of FINS data.

This analysis revealed that 2-day small parcel delivery cost an average of 24.02% less than 1-day delivery. This cost factor was applied to 1-day air small parcel rates to obtain 2-day air small parcel rates.

7. On-base Issues. Transportation cost for on-base issues was assumed to be negligible.

8. Dedicated Trucks. Existing dedicated truck routes and transportation costs cannot be assumed under DLA's new stock positioning policy. Therefore, in an effort to be consistent in our rating methodology, the transportation cost for materiel moving under any dedicated truck route was based on GT agreements for surface freight (40,000 pound) rates.

9. First Destination. All of the other transportation costs discussed in this section relate to second destination transportation. This item relates only to first destination transportation (vendor to depot) costs. These costs are typically included in the acquisition cost of materiel, are not covered under GT agreements, and become important when evaluating stock-positioning alternatives. Small parcel shipments were rated using current UPS rates and freight shipments were rated using current commercial class 50 rates discounted 10 percent.

With the exception of on-base issues and materiel enroute by dedicated truck, the baseline transportation costs were obtained by shipping the Issue Priority Group (IPG) III materiel and priority freight less than 400 miles via surface, the remainder of IPG II materiel via 2-day air, and the remainder of IPG I materiel via 1-day air. Each of these transportation modes, of course, have different in-transit times (our discussion of in-transit times is presented in the next section). By varying the transportation mode, we were able to evaluate how transportation costs change when in-transit times are reduced.

SECTION A-8: IN-TRANSIT TIMES

A-8.1 BACKGROUND

In-transit time starts with the date that materiel is shipped from the distribution depot and ends with the date that materiel is delivered to the Central Receiving Point (CRP) or the customer. Different transportation modes have different in-transit times. Generally, a reduction of in-transit time is accomplished by using a more expensive mode of transportation. In this section, we develop in-transit times for different modes of transportation.

A-8.2 METHODOLOGY

The Freight Information File (FINS) contains in-transit data by carrier for materiel that is shipped under a Government Bill of Lading (GBL) using Guaranteed Traffic Agreements. Using FINS data from January 1994 through September 1994, we developed average in-transit times for Truckload (TL) and Less-Than-Truckload (LTL). Since in-transit time for surface small parcel is incomplete in FINS, we obtained in-transit information from published carrier standards. Table A-10 provides the average in-transit times used for these surface modes.

Mileage Range	TL	LTL	Mileage Range	Small Parcel
0- 400	2.1	3.5	0- 150	1
401- 800	2.9	5.0	151- 450	2
801-1200	4.1	6.4	451- 900	3
1201-1600	4.7	7.1	901-1500	4
1601-2000	5.5	7.6	1501-2000	5
2001-2400	6.4	8.5	Over 2000	6
2401-2800	7.0	9.1		
Over 2800	7.5	10.0		

Table A-10. Average In-Transit Times (Days) For Surface Modes

Again, using FINS data from January 1994 through September 1994, we developed average in-transit times for air small parcel and air freight. We observed that transportation by air is insensitive to distance. Therefore, we assumed that the in-transit times for all air modes was one day for overnight service and two days for second-day air service.

APPENDIX B

BIBLIOGRAPHY

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BIBLIOGRAPHY

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Every inch that we can take off of the logistics pipeline is known to result in reduced customer inventories; and therefore, it reduces costs to the taxpayer. However, unlike many other DLA response time reduction initiatives, this report addresses response time reductions in areas that are known to have cost implications to the wholesale organizations. Many logisticians believe that these added costs will be minimal in light of the potential retail inventory reductions associated with faster wholesale replenishment. In this report we quantify the costs incurred by DLA as depots reduce requisition bank time, hold time, and in-transit time. Furthermore, we investigated different stock positioning issues relating to range and depth of stock in order to provide a reduced response time at the lowest possible cost.

14. SUBJECT TERMS

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